EFFECTS OF DIFFERENT SOWING DATES (AMBIENT DAY LENGTH) ON FLOWERING TIME OF IMPORTANT ORNAMENTAL ANNUALS

Jalal-ud-Din Baloch[1], Muhammad Qasim Khan[1], Muhammad Zubair[2] and Muhammad Munir[3]

[1]Faculty of Agriculture, Gomal University, Dera Ismail Khan(NWFP)Pakistan.
[2] University College of Agriculture, Bahaudin Zakariya University, Multan, Pakistan.
[3] School of Plant Sciences, The University of Reading, Reading, U.K.

ABSTRACT

Present study was carried out at Agricultural Research Institute, D. I. Khan, Pakistan, during the year 2004-2005. Seeds of six SDPs (Zinnia cv. Lilliput, Sunflower cv. Elf, French Marigold cv. Orange Gate, African Marigold cv. Crush, Cockscomb cv. Bombay and Cosmos cv. Sonata Pink) and ten LDPs (Moss Rose cv. Sundance, Pansy cv. Baby Bingo, Snapdragon cv. Coronette, Petunia cv. Dreams, Pot Marigold cv. Resina, Annual Phlox cv. Astoria Magenta, Cornflower cv. Florence Blue, Oriental Poppy cv. Burning Heart, Flax cv. Scarlet Flax and Annual Verbena cv. Obsession,) were sown at 15 days interval in their responsive growing season i.e. SDPs from September to January (short day length) and LDPs from March to July (long day length). SDPs were raised from 1st September to 15th December and LDPs from 1st March to 15th June showed a non-significant (P<0.05) difference in days taken to flowering. However, a significant (P<0.05) difference was observed when late sowing dates (1st and 15th January in SDPs and 1st and 15th July in LDPs) were compared with the rest. It is therefore concluded that very late sowing in either case significantly delayed flowering time because SDPs of late sowing dates (1st and 15th January) received long days and more light integrals at flower development stage hence increased flowering time. Similarly, LDPs raised from 1st to 15th July received short day length and less light integrals at floral development stage which enhanced flowering time.

Keywords
Sowing dates, day length, flowering time, ornamental annuals.

INTRODUCTION

Day length refers to the temporal length of a day, during which there is daylight. Due to the diffusion and refraction of sunlight by the atmosphere, there is actually daylight even when the sun is slightly below the horizon. Day length can be computed from the moment the upper limb of the sun's disk appears on the horizon during sunrise to the moment when the upper limb disappears at the horizon during sunset. Day length is critical to the growth and lifecycle of many plants. Growers of ornamental annuals often supplement natural light to take a plant into a different time of the year. Seeds need to be planted at the right time. If seeds are sown too early, bad weather will destroy the crop. If sown late, it will not have sufficient time to mature. Many plants use the length of the day to judge when to flower. Different cultivars of plants react to day length in different ways.

Plant uses energy from sunlight to power its growth. Temperature, nutrient levels in the soil and water are all important but without sunlight plants will not grow. The more sunlight, the more energy is available for the plant to power that growth. The longer that a day lasts, the more time there is for earth to absorb energy from the sun. Thus, longer days typically result in warmer days, while shorter days result in cooler days (Thomas and Vince-Prue, 1997).

Flowering of ornamental plants is not only important for their continued propagation but also for displaying the plant at its most attractive point of sale. Flower development of many ornamental annuals is harmonized during the season by using changes in day and night length, which indicates that the flowering response is photoperiodic (Garner and Allard, 1920). Broadly, flowering plants can be classified as long day plants (LDPs), short day plants (SDPs), or day neutral plants (DNPs). LDPs are plants that flower when the day is longer than a critical length (i.e. the night is shorter than a critical length). These plants generally flower in the spring or early summer, as days are getting longer. SDPs are plants that flower when the day is shorter than a critical length, or the night is longer than a critical length. These plants generally flower in late summer or fall, as days get shorter (Thomas and Vince-Prue, 1997).

The knowledge of plant response to different day length facilitates gardeners to grow them year round to maintain their constant supply in the market. In recent years, the importance of ornamental plants scheduling has greatly increased particularly in countries, which are earning sufficient foreign exchange through ornamental export. This increased emphasis on scheduling is focused primarily on mass demands of the market for consistency in product and presence of flowers at sale time. Vernieri *et al.* (2003) reported that time of flowering reduced significantly when sunflower was sown early. Plant growth and development is also affected by early or late sowing time (Justes *et al.*, 2002; Balkaya *et al.*, 2004; Karaguzel *et al.*, 2005; Sundeep *et al.*, 2005; Wang *et al.*, 2006). As annual ornamental plants provide a display for a limited period therefore there is relatively short market season for these crops. If the crop is matured early or late, it will be wasted. Therefore, there is an intense need to understand how plant induce flowering when the day length is increased or decreased to regulate the supply of these flowering crops to the market (Pearson *et al.*, 1994) which would be most beneficial for the growers involved in this business. Keeping in view the importance of plant scheduling, an experiment was designed to examine an applied possibility of plant scheduling of various ornamental annuals by sowing them at different dates.

MATERIALS AND METHODS

Present experiment was conducted at Agricultural Research Institute, D. I. Khan, Pakistan, during the year 2004-2005. Seeds of SDPs such as Zinnia (*Zinnia elegans* L.) cv. Lilliput, Sunflower (*Helianthus annuus* L.) cv. Elf, French Marigold (*Tagetes Patula* L.) cv. Orange Gate, African Marigold (*Tagetes erecta* L.) cv. Crush, Cockscomb (*Celosia cristata* L.) cv. Bombay, Cosmos (*Cosmos bipinnatus* Cav.) cv. Sonata Pink were sown from 1st of September to 15th of January 2004 at 15 days interval. Similarly, seeds of LDPs such as Moss Rose (*Portulaca grandiflora* L.) cv. Sundance, Pansy (*Viola tricolour hortensis* L.) cv. Baby Bingo, Snapdragon (*Antirhinum majus* L.) cv. Coronette, Petunia (*Petunia* × *hybrida* Juss.) cv. Dreams, Pot Marigold (*Calendula officinalis* L.) cv. Resina, Annual Phlox (*Phlox drummondii* L.) cv. Astoria Magenta, Cornflower (*Centaurea cyanus* L.) cv. Florence Blue, Oriental Poppy (*Papaver orientale* L.) cv. Burning Heart, Flax (*Linum usitatissimum* L.) cv. Scarlet Flax and Annual Verbena (*Verbena* × *hybrida* L.) cv. Obsession were sown from 1st of March to 15th of July 2005 at 15 days interval. The reason of planting SDPs between September and January (short day length) and LDPs between March and July (long day length) was to estimate flowering character under their respective responsive environment.

Seeds of all cultivars were sown into module trays containing locally prepared leaf mould compost. Seed trays were kept at room temperature at night and they were moved out during the day (08:00–16:00 h) under partially shaded area. After 70% seed germination, six plants of each cultivar were shifted to the experimental area where they were potted into 9cm pots containing leaf mould compost and river sand (3:1 v/v) after 6 leaves emerged. Plants were irrigated by hand and a nutrient solution [(Premium Liquid Plant Food and Fertilizer (NPK: 8-8-8); Nelson Products Inc. USA)] was applied twice a week. Mean diurnal temperature was recorded by using a hygrothermograph **(**225-5020-A Hi-Q Hygrothermograph, NovaLynx Corporation, USA) whereas the solar radiation (photosynthetic active radiation, PAR, also called as light integrals) was recorded by solarimeters. These devices were installed in the weather station one kilometer away from the research site (Table 1). Plants in each treatment were observed daily until flower opening (corolla fully opened). Numbers of days to flowering from emergence were recorded at harvest and the data were analysed using GenStat-8 (Lawes Agricultural Trust, Rothamsted Experimental Station, U.K. and VSN International Ltd. U.K.).

Table 1 Environmental detail of the experiment conducted in 2004-2005

Growing Season	Diurnal temperature (°C)			Ambient day length ($h.d^{-1}$)	Daily light integral ($MJ.m^{-2}.d^{-1}$)
	Maximum	Minimum	Average		
SDPs: Zinnia, Sunflower, French Marigold, African Marigold, Cockscomb, Cosmos					
September, 2004	36.23	23.57	29.90	14.25	9.35
October, 2004	29.74	19.10	24.42	13.12	8.32
November, 2004	26.97	10.67	18.82	12.39	7.31
December, 2004	22.48	6.77	14.63	12.15	7.13
January, 2005	18.81	4.03	11.42	12.12	7.23
February, 2005	18.96	6.96	12.96	12.52	7.33
LDPs: Moss Rose, Pansy, Snapdragon, Petunia, Pot Marigold, Annual Phlox, Oriental Poppy, Cornflower, Flax, Annual Verbena					
March, 2005	26.19	13.29	19.74	13.30	8.43
April, 2005	32.87	15.73	24.30	14.21	9.45
May, 2005	36.39	20.35	28.37	15.40	9.40
June, 2005	42.27	30.70	36.48	16.16	9.99
July, 2005	36.77	25.68	31.23	16.14	9.42
August, 2005	37.48	30.23	33.85	15.06	9.06
September, 2005	36.03	24.50	30.27	14.25	9.62
October, 2005	33.16	17.13	25.15	13.12	8.75
November, 2005	26.87	9.53	18.20	12.39	7.53

RESULTS

Time taken to flowering by SDPs such as Zinnia cv. Lilliput, Sunflower cv. Elf, French Marigold cv. Orange Gate, African Marigold cv. Crush, Cockscomb cv. Bombay, Cosmos cv. Sonata Pink was increased significantly (P<0.05) when seeds were sown at later dates i.e., 1st and 15th January. However, a non-significant trend was observed from 1st September to 15th December sowing dates in almost all cultivars of SDPs. A 19 days difference between early sowing dates and that of 15th January was recorded in Zinnia cv. Lilliput (Fig. 1A). Early planting zinnia (1st September to 1st December) took 70-71 day to flower. There was a significant (P<0.05) increase in time to flowering from 15th December sowing dates to 15th January. Seeds sown on 15th December took 76 days to flower whereas 1st and 15th January sowing dates took 81 and 89 days to flower respectively. Fig. 1B showed 19 days difference between early sowing dates and late sowing date (15th January) in Sunflower cv. Elf. Sunflower grown on 1st and 15th September took 73 and 72 days respectively whereas sunflower grown from 1st October to 1st December flowered after 71 days and that of 15th December to 15th January took significantly (P<0.05) more days to flower i.e., 76 (15th December), 82 (1st January) and 90 (15th January). Difference between early sowing date and late one was 11 days regarding days to flowering of French Marigold cv. Orange Gate (Fig. 1C). Early sowing date, from 1st September to 15th December took 60-62 days to flower whereas late sowing dates such as 1st December and 15th December produced flowers after 72 and 78 days respectively, which were significantly ($P<0.05$) different with rest of the sowing dates. A similar trend was observed in African Marigold cv. Crush (Fig. 1D) and a 13 days difference in time to flower was noted between early (September-December) and late (January) sowing dates. Plants sown between 1st September to 15th December took 66-68 days to flower whereas time to flowering significantly ($P<0.05$) increase in later sowing dates i.e., 1st January (72 days) and 15th January (79 days). Fig. 1E depicted a 13 days difference between 1st September to 15th December (94-95 days) sowing date and that of 15th January one (110 days) in Cockscomb cv. Bombay. Early planting cockscomb (1st September to 1st December) took 94-95 day to flower. After 1st December a significant ($P<0.05$) increase in flowering time was observed in the following plantings on 15th December (99 days), 1st January (104 days) and 15th January (110 days). Similarly, Fig. 1F showed a 15 days difference between early sowing dates (1st September to 1st December) and late sowing date (15th January) in Cosmos cv. Sonata Pink. Cosmos grown on 1st September to 1st December took 59-61 days to flower. Time to flowering increased significantly ($P<0.05$) at later sowing dates of 15th December (65 days), 1st January (69 days) and 15th January (74 days).

Late seed sowing indicated a statistically significant ($P<0.05$) difference in flowering time in LDPs such as Moss Rose cv. Sundance, Pansy cv. Baby Bingo, Snapdragon cv. Coronette, Petunia cv. Dreams, Pot Marigold cv. Resina, Annual Phlox cv. Astoria Magenta, Cornflower cv. Florence Blue, Oriental Poppy cv. Burning Heart, Flax cv. Scarlet Flax and Annual Verbena cv. Obsession. Non-significant difference was observed from 1st September to 15th December sowing dates in most cultivars of LDPs. Plants of Moss Rose cv. Sundance flowered 10 days late when grown on 15th July as compared to early sowing dates from March to June (Fig. 2A). Plants of early sowing dates (1st and 15th March and 1st April) flowered after 59, 57 and 56 days however it took 55 days to flower (15th April to 1st June) afterward. A significant ($P<0.05$) increase in flowering time was observed when plants were grown on 1st and 15th July as they took 60 and 65 days to bloom. Similarly, Pansy cv. Baby Bingo (Fig. 2B) took 50 days to flower in early sowing dates as compared to 60 days in late sowing time (10 days difference). Plants of early sowing dates (1st and 15th March) took 52-54 days to flower however plants grown from April to June took 50-51 days to flower. A significant ($P<0.05$) difference in flowering time was observed from 1st July (55 days) to 15th July (60 days) sowing dates. Fourteen (14) days difference between early sowing dates and late one (15th July) was recorded in Snapdragon cv. Coronette (Fig. 2C). Plants took 82 days to flower in early sowing dates 1st and 15th March and 1st April. Flowering time was reduced (79-80 days) in subsequent sowing dates i.e., from 15th April to 15th May. However, it increased significantly ($P<0.05$) after 15th June to 15th July showing 85 days (15th June), 90 days (1st July) and 93 days (15th July). A 13 days early flowering was recorded in Petunia cv. Dreams (Fig. 2D) when they were sown between 1st May and 1st June as they took 55 days to flower. Plants of earlier sowing dates (1st March to 15th April) took 56-58 days to flower. Time to flowering slightly increased (60 days) from later date 15th June however it increased significantly ($P<0.05$) from 1st July (64 days) to 15th July (68 days). A 10 days difference between early sowing time (March to June) and late sowing time (15th July) was observed in Pot Marigold cv. Resina (Fig. 2E). Plants of early sowing dates (1st March to 15th June) flowered after 70-71 days. However, a significant ($P<0.05$) increase in flowering time was observed when plants were grown on 1st and 15th July taking 75 and 80 days to flower. Similarly, Annual Phlox cv. Astoria Magenta (Fig. 2F) took 70-71 days to flower in early sowing dates (1st March to 15th June) as compared to 76 and 81 days in late sowing time of 1st to 15th July (10 days late flowering). The flowering time difference between July and rest of the months (March-June) was statistically significant ($P<0.05$).

Time to flowering was increased up to 9 days when Cornflower (cv. Florence Blue) was planted late (15th July). Fig. 3A showed that plants sown between 1st March to 15th June took 79-80 days to flower however on 1st July sowing date it took 84 followed by 88 days (15th July) which was significantly ($P<0.05$) different from the rest of sowing time i.e., 1st March to 15th June. On the other hand, Oriental Poppy cv. Burning Heart (Fig. 3B) took 64 days to flower in early sowing dates (1st March to 15th June) as compared to 75 days in late sowing date (11 days difference). Plants of early sowing dates (1st March to 15th June) took 64-65 days to flower. However, a significant ($P<0.05$) difference in flowering time was observed from 1st July (70 days) to 15th July (75 days) sowing dates. Flax cv. Scarlet Flax flowered 12 days earlier when grown between 1st March to 15th June (Fig. 3C). Plants of the referred sowing dates took 80-83 days to flower, which was significantly ($P<0.05$) different than those grown during 1st and 15th July taking 88 and 93 days to flower respectively. On the other side, Annual Verbena cv. Obsession showed 10 days significant difference ($P<0.05$) between last sowing date (15th July) and the rest (Fig. 3D). There was a non-significant difference among plants grown on earlier dates (1st March to 15th June) that took 50 days to flower. However, time to flowering was accelerated 5 to 10 days when plants were sown at 1st and 15th July (54 and 60 days to flower, respectively).

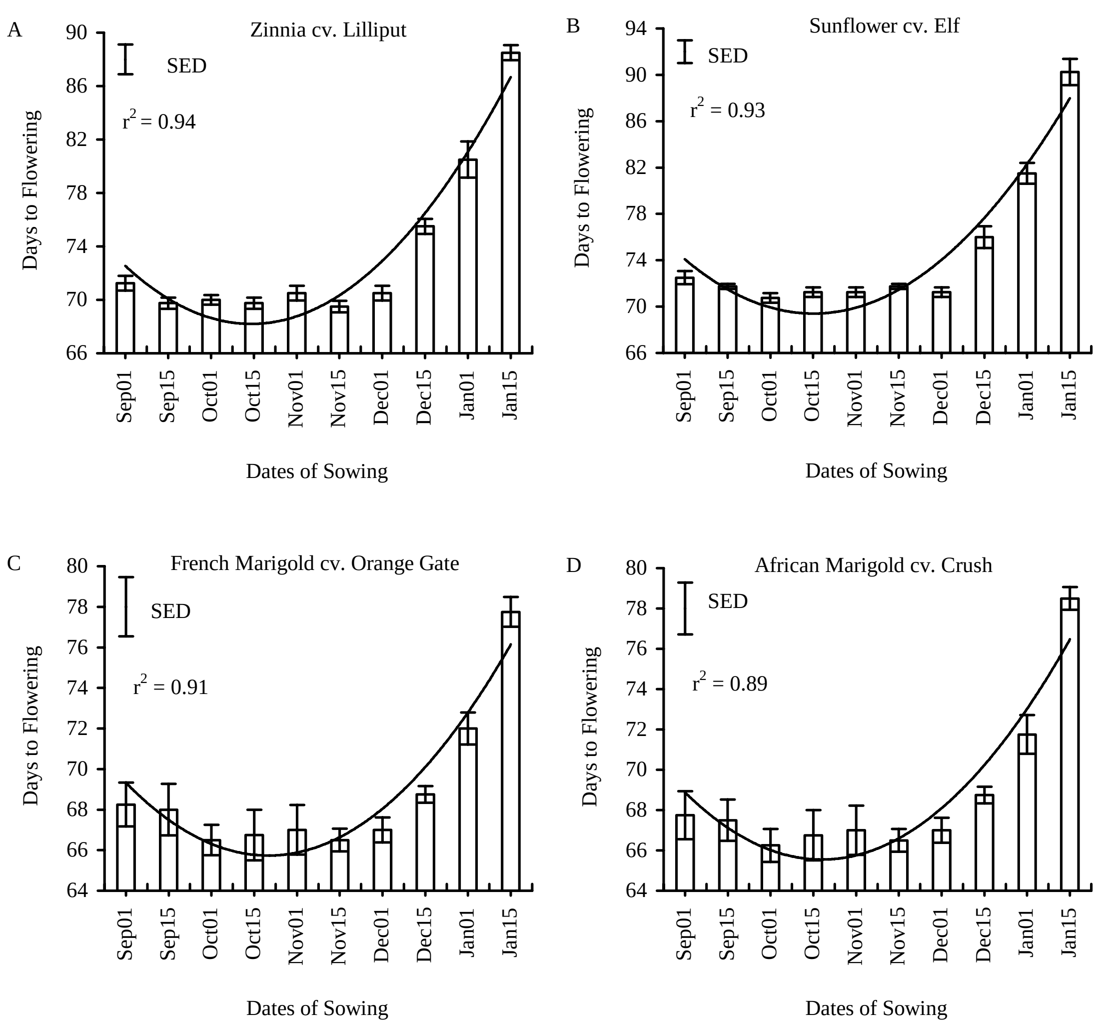
DISCUSSION

The findings of present research showed that very late sowing of either SDPs or LDPs increased time to flowering which is also reported in other crops (McDonald *et al.*, 1994; Trongkongsin and Humphreys 1988). Different cultivars (early, medium and late) of *Eustoma grandiflorum* were grown year round for consistent supply to the market (Takashi *et al.*, 1998). However, in present study only one cultivar of each important ornamental annual has been grown for five months and they displayed flower for a long duration. For example, SDPs such as Zinnia, Sunflower, French Marigold, African Marigold, Cockscomb and Cosmos flowered from end of November to April. Similarly, LDPs such as Moss Rose, Pansy, Snapdragon, Petunia, Pot Marigold, Annual Phlox, Cornflower, Oriental Poppy, Flax and Annual Verbena flowered from end of May to October. This year round display of colours could be further extended by manipulating other environmental factors such as photoperiod, temperature and light integrals (Munir, 2003; Pearson *et al.*, 1994).

The flowering time of cultivars depends on their inherent development rate, their response to temperature and day length, or all three factors (Thomas and Vince-Prue, 1997). If a crop sown late it will flower late and *vice versa*. In present research first 7-8 dates of sowing in either case (SDPs and LDPs) took almost similar days to flower. The reason could be that the plants received more or less same temperature, day length and light integrals during their growing period. However, flowering time was enhanced when plants were sown late (last 2-3 sowing dates). Again the said environmental factors might play a major role in the growth and development process hence increased flowering time. For example, Zinnia and Sunflower when raised after 15th December until 15th January increased flowering time up to 19 days. The same results were obtained with French Marigold (11 days), African Marigold (13 days), Cockscomb (15 days) and Cosmos (16 days). This indicated that when late sowing plants completed juvenile phase and entered in to reproductive phase (phase change) the flower induction process was entrapped because of poor stimulus (Battey and Tooke, 2002). In this case (SDPs) day length was increased from 12.12 to 14.21 $h.d^{-1}$ and light integrals (PAR) were increased from 7.13 to 9.45 $MJ.m^{-2}.d^{-1}$. At phase change stage plants were either expecting a continuous flow of signals (Battey and Lyndon, 1990) from leaf to apex (O'Neil, 1992) or a small pulse is sufficient to commit induction (Bradley *et al.*, 1997), which in the other way round affect apex to perceive the stimulus and hence increased time to flowering. Similar results were obtained in LDPs. Late sowings dates, from 15th June to 15th July affected flowering time significantly. The same justification can be mentioned here. The day length (from 16.14 to 12.39 $h.d^{-1}$) and light integrals (from 9.42 to 7.53 $MJ.m^{-2}.d^{-1}$) decreased when LDPs entered in to phase change stage therefore they took more time to flower (Munir, 2003).

CONCLUSION

The flowering time of a cultivar can affect decisions on time of sowing. Thus, it is concluded from the present investigation that SDPs require short day length and lower PAR therefore are suitable to grow in winter and take less time to flower but the display time could be enhanced if sown in late winter. Similarly, LDPs require long day length and higher PAR therefore they can be grown in summer. However, their time to flower could be extended if grow them in late summer.



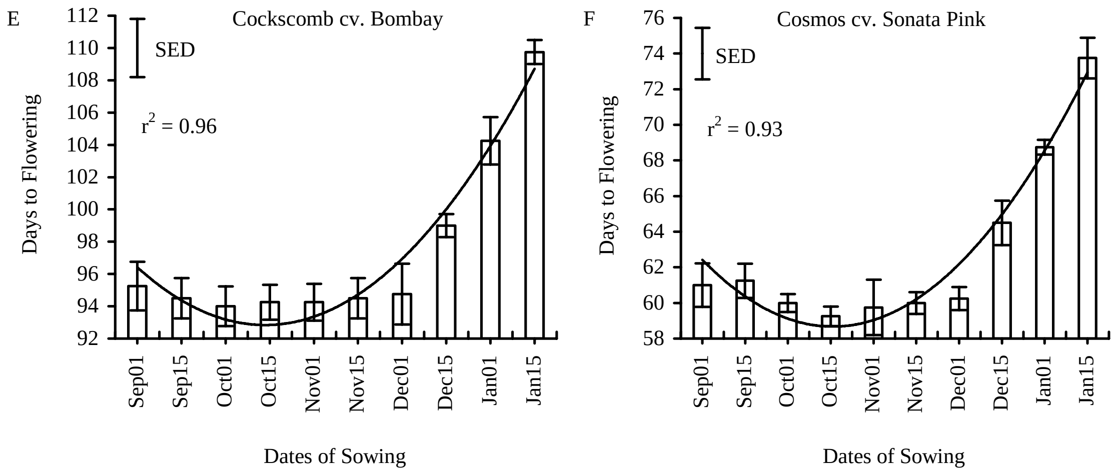
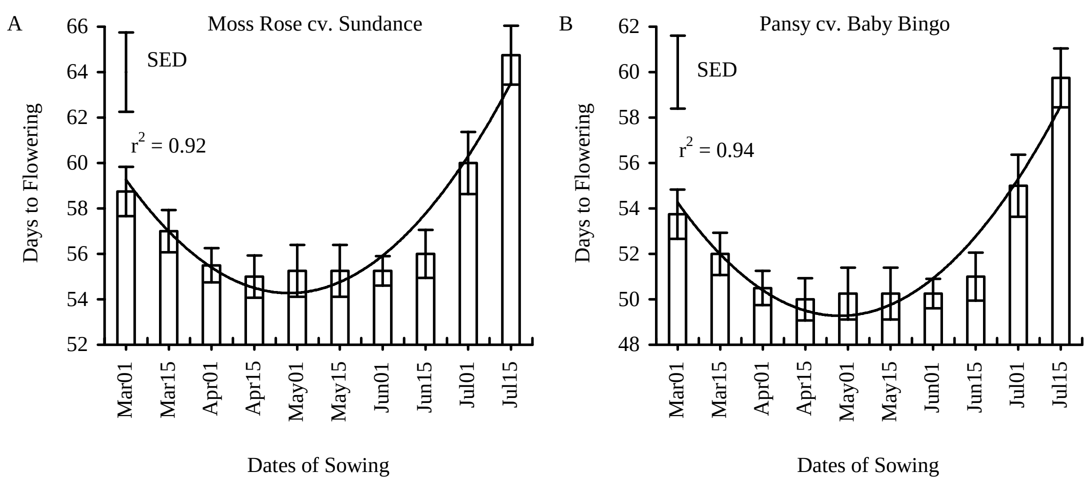


Fig. 1: Effect of different sowing dates (day length) on the flowering time of (A) Zinnia cv. Lilliput, (B) Sunflower cv. Elf, (C) French Marigold cv. Orange Gate, (D) African Marigold cv. Crush, (E) Cockscomb cv. Bombay and (F) Cosmos cv. Sonata Pink. Each point represents the mean of 6 replicates. Vertical bars on data points (where larger than the points) represent the standard error within replicates whereas SED vertical bar showing standard error of difference among means.



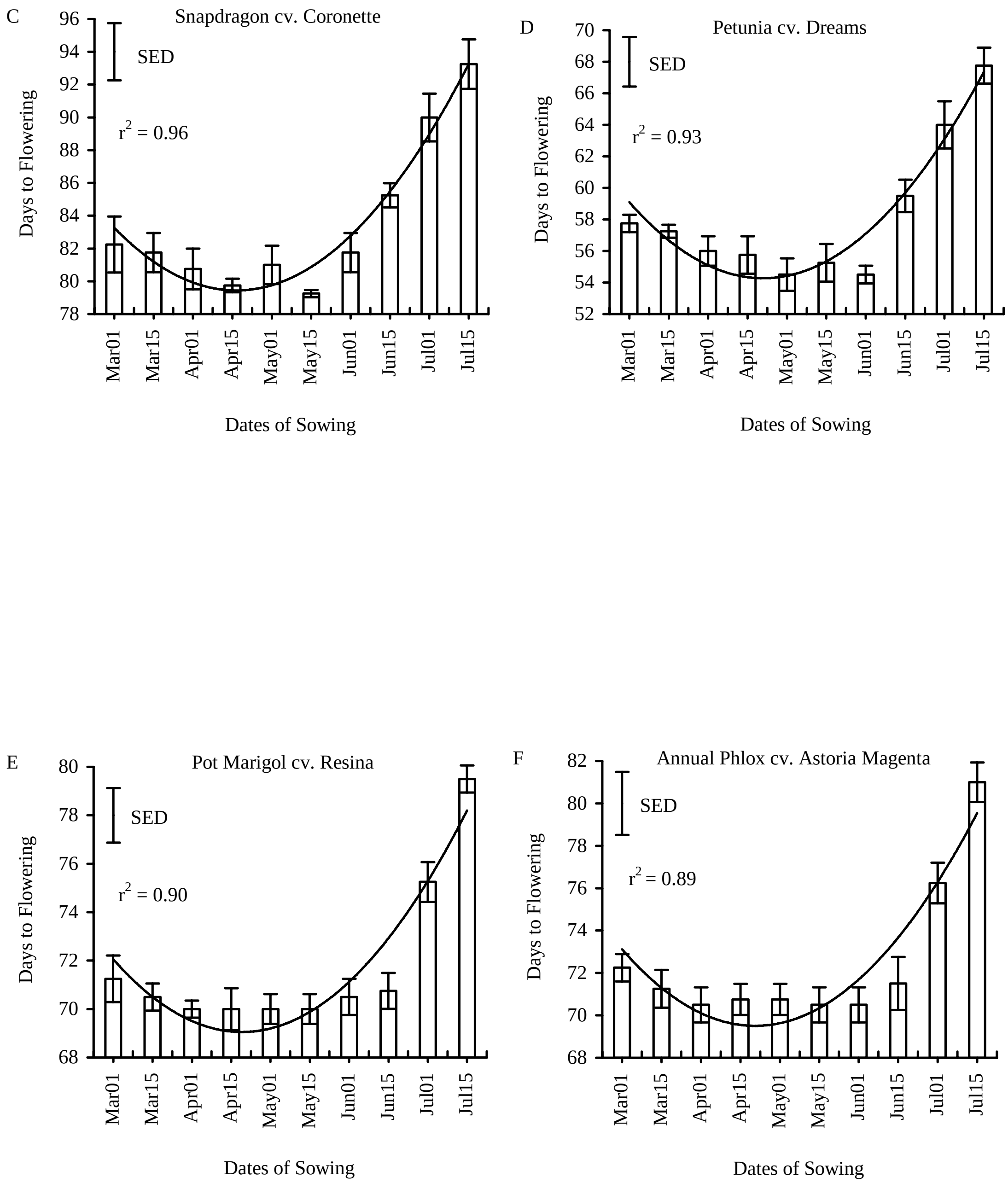


Fig. 2: Effect of different sowing dates (day length) on the flowering time of (A) Moss Rose cv. Sundance, (B) Pansy cv. Baby Bingo, (C) Snapdragon cv. Coronette, (D) Petunia cv. Dreams, (E) Pot Marigold cv. Resina and (F) Annual Phlox cv. Astoria Magenta. Each point represents the mean of 6 replicates. Vertical bars on data points (where larger than the points) represent the standard error within replicates whereas SED vertical bar showing standard error of difference among means.

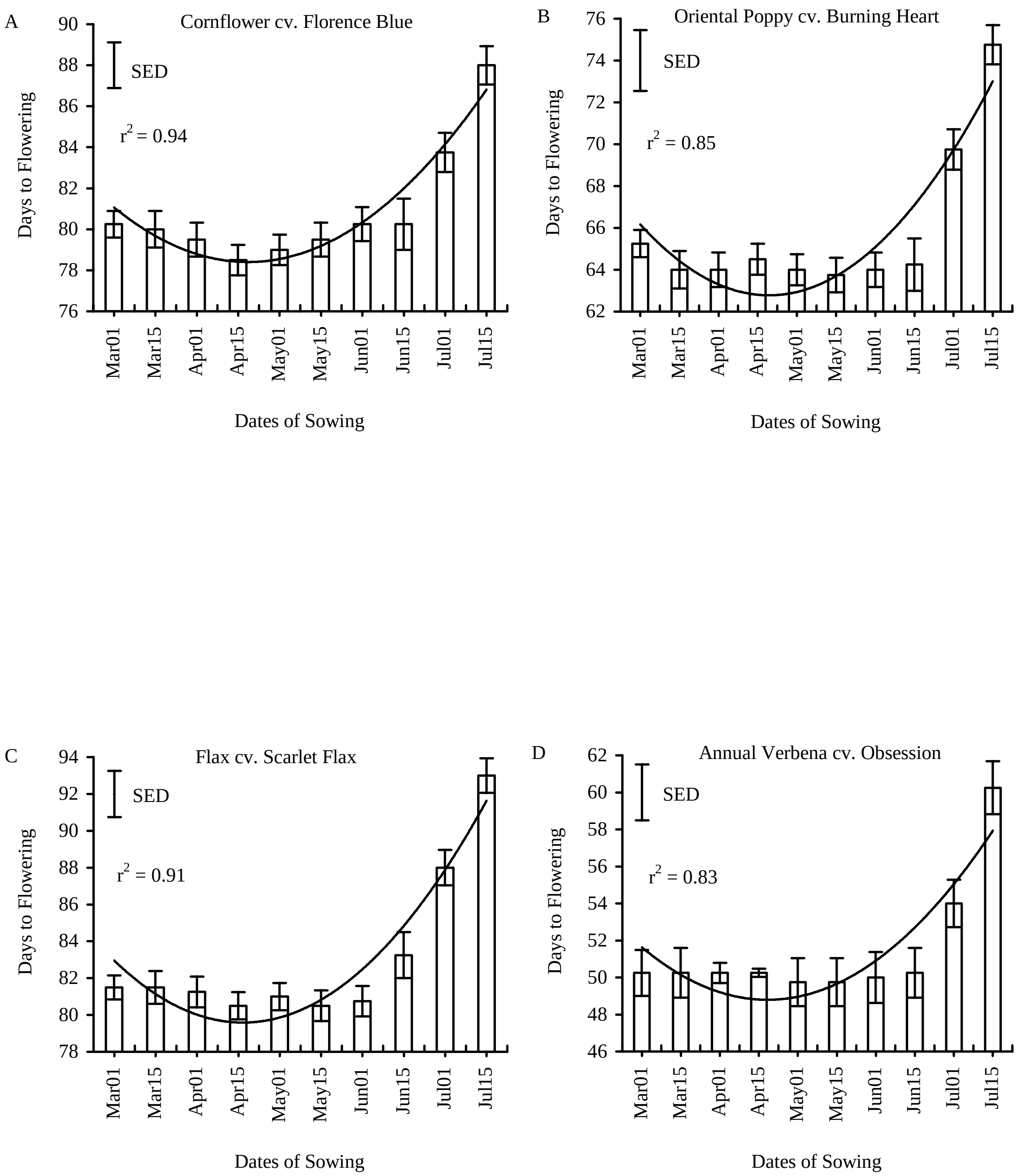


Fig. 3: Effect of different sowing dates (day length) on the flowering time of (A) Cornflower cv. Florence Blue, (B) Oriental Poppy cv. Burning Heart, (C) Flax cv. Scarlet Flax and (D) Annual Verbena cv. Obsession. Each point represents the mean of 6 replicates. Vertical bars on data points (where larger than the points) represent the standard error within replicates whereas SED vertical bar showing standard error of difference among means.

REFERENCES

Balkaya A, Uzun S and Odabas M S (2004). Determination of the relationship between the sowing times and plant light interception in red podded bean growing. Asian J. Plant Sci., 3: 223-230.

Battey N H and Tooke F (2002). Molecular control and variation in the floral transition. Cur. Op. Plant Bio., 5: 62-68.

Battey N H and Lyndon R F (1990). Reversion of flowering. Bot. Rev., 56: 162-189.

Bradley D, Ratcliffe O, Vincent C, Carpenter R and Coen E (1997). Inflorescence commitment and architecture in *Arabidopsis*. Science, 275: 80-83.

Garner W W and Allard H A (1920). Effect of the relative length of day and night and other factors of the environment on growth and reproduction in plants. J. Agril. Res., 18: 553-606.

Justes E, Thiebeau P, Avice J C, Lemaire G, Volenec J and Alain O (2002). Influence of summer sowing dates, N fertilization and irrigation on autumn VSP accumulation and dynamics of spring regrowth in alfalfa (*Medicago sativa* L.) J. Expt. Bot., 53: 111-121.

Karaguzel O, Baktir I, Cakmakci S, Ortacesme V, Aydinoglu B and Atik M (2005). Responses of native *Lupinus varius* (L.) to culture conditions: effects of photoperiod and sowing time on growth and flowering characteristics. Sci. Hort., 103: 339-349.

McDonald G K, Adisarwanto T and Knight R (1994). Effect of time of sowing on flowering in faba bean (*Vicia faba*). Aust. J. Expl. Agric., 34: 395-400.

Munir M (2003). A study on the effects of environmental factors affecting the phases of flower development in *Antirrhinum majus* L. Ph.D. Thesis. Department of Horticulture and Landscape, School of Plant Sciences, The University of Reading, U.K.

O'Neil (1992). The photoperiodic control of flowering: Progress toward the understanding of the mechanism of induction. Photochem. Photobio., 56: 789-801.

Pearson S, Hadley P, May D R, Parker A and Adams S R (1994). The effect of temperature on bedding plants. Rep. Hort. Dev. Council. PC74.

Sudeep S, Buttar G S, Singh S P and Brar D S (2005). Effect of different sowing dates and row spacings on yield of coriander (*Coriandrum sativum*). J. Medicinal and Aromatic Plant Sci., 27: 301-302.

Takashi Y, Kazuto T, Yasuhiro F, Ken'ichiro O and Mariko E (1998). Controlling flowering in *Eustoma grandiflorum* by sowing time, heating, low-temperature treatment of rosette seedlings, and cultivar selection in Ishikawa prefecture. Bulletin of the Ishikawa Agri. Res. Cen., 21: 27-35.

Thomas B and Vince-Prue D (1997). Photoperiodism in plants. London. Academic Press.

Vernieri P, Malfa G, Lipari V, Incrocci G, Noto G, Tognoni F, Serra G and Leonardi C (2003). Effect of cultivar, timing, growth retardants, potting type on potted sunflowers production. Acta Hort., 614: 313-318.

Wang T, Zhou D, Wang P and Zhang H (2006). Size-dependent reproductive effort in *Amaranthus retroflexus*: the influence of planting density and sowing date. Canadian J. Bot., 84: 485-492.